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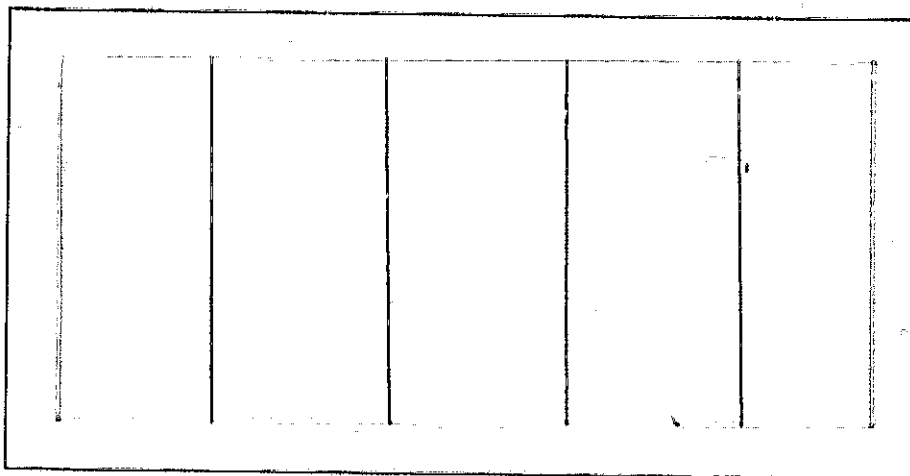
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SCIENCE Applications INCORPORATED

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CONTENT IN THE ATMOSPHERE FROM LANDSAT DATA
Progress Report, 1 Aug. 1976 - 31 Jan. 1977
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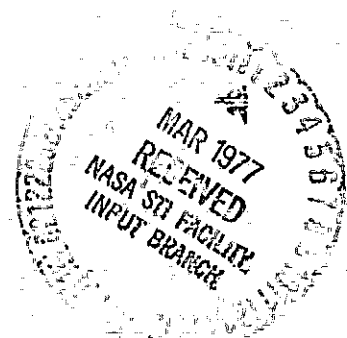
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DETERMINATION OF AEROSOL CONTENT
IN THE ATMOSPHERE FROM
LANDSAT DATA

Progress Report Nos. 7 and 8

Contract No. NAS5-20899

I.D. Number 22260

Period Covered: August 1, 1976 to
January 31, 1977

Principal Investigator: Dr. M. Griggs

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Prepared for:

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ACCOMPLISHMENTS

In this period, Volz measurements were made at San Diego; Volz data and Landsat digital data were analyzed for other sites, and the analysis of the raw data CCT's was completed.

Landsat Data

In this period digital data for nineteen Landsat 2 overpasses at San Diego, Salton Sea, Miami, Atlantic City, Barrow, and Adrigole have been analyzed; three Landsat 1 overpasses have been analyzed for San Diego.

The Landsat 2 data are shown in Figure 1 for San Diego and the Salton Sea, and in Figure 2 for the other sites. A tabulation of all Landsat 2 data analyzed in the program to date is given in Table 1. The Landsat 1 data are presented in Figure 3 and in Table 2.

Landsat 2 - San Diego and Salton Sea. The three points for San Diego agree well with the previous San Diego data. Of the three Salton Sea points, two agree with the San Diego data (and two earlier Salton Sea points), but one appears high and in agreement with four earlier Salton Sea points. The reason for these five Salton Sea points showing apparently high radiance values is not clear. The conditions on these days did not appear different from other overpasses, i.e., no obvious water turbidity or sun glitter, which could produce higher radiances. The

possibility that the Volz reading is in error is discounted; also, it is unlikely that the atmospheric aerosol content would vary by about 0.5N (necessary for these radiances to agree with the other data) between the Volz site on shore and the area analyzed, about 2 km off-shore.

Landsat 2 - Adrigole. Only two sets of Landsat data were obtained for the period March to September 1976. The first set of data (0.76N) shows excellent agreement with other Landsat 2 data. This is of great interest since the point represents another body of water and Volz observations by another observer and instrument, suggesting that indeed the radiance-aerosol content relationship can be applied globally. The second Adrigole point (2.0N) does not agree quite so well, with the radiance being lower than expected. This is probably explained by the presence of a veil of cirrus over the area, which is clearly visible in the B&W print, although the Volz observer reported only 0.5 cloud cover, and the fact that the Volz reading was not taken precisely at the time of the overpass. The value of 2.0N was linearly interpolated from measurements of 1.85N two hours before the overpass and 2.05N one hour after; of course, with the presence of clouds considerable error can occur in the interpolation.

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Landsat 2 - Barrow. During the March-September 1976 period there was considerable cloud cover at the time of the overpasses, and the body of water near the Volz site was frozen over most of the time. One overpass has been analyzed, and the digital data for one more are on order. Unfortunately, the one overpass analyzed does not provide a valid set of data for this investigation since the closest body of water was about 40 km from the Volz site, due to the presence of ice. Hence it is likely that the aerosol content over the water was different from that measured (0.51N) with the Volz photometer. The radiances, shown in Figure 2, appear high in each MSS channel, and would look more reasonable if the aerosol content were about 1.25N.

Landsat 2 - Atlantic City. Six sets of data have been analyzed for the period March-September 1976, and one set is on order. These data are for high aerosol contents, with five of the six overpasses being greater than 2.3N. The points generally are as anticipated, although the 1.79N, 2.35N radiances tend to be somewhat low in all MSS channels, and the 3.38N radiances appear low in MSS 5, 6 and 7. These radiances are measured over a reservoir (approximately 300 x 2000 m) near the Volz site rather than over the ocean or a large body of water. The tendency toward lower radiances is surprising since radiances generally are higher rather than lower due to water pollution effects. Also for this site the small area of water is surrounded by land which has a higher reflectivity than water and would tend to increase the

observed radiance. The results for this site suggest that it might be possible to determine the aerosol content over small bodies (with unpolluted water) in urban areas.

Landsat 2 - Grand Prairie. No data were analyzed for this site due to the presence of water turbidity in the lake near the Volz site. Apparently this lake (Mountain Creek Lake) is quite muddy and sometimes clearly shows high chlorophyll content. On the basis of this and the Landsat B&W prints received for this site, it appears that this lake is not useful in this investigation.

Landsat 2 - Miami. The results for four overpasses are shown in Figure 2. No results are shown for MSS 4 and 5 since the ocean is clear and shallow at this site, and bottom reflectance increases the observed radiances in these channels. The radiances in MSS 6 and 7 agree quite well with the expected values, although they may be slightly lower; this is probably due to the very clear water, i.e., there is no water turbidity enhancing the radiance as probably occurs to some degree at all sites. Other Miami overpasses were not analyzed since we are essentially obtaining useful data for only one channel, since MSS 7 is subject to calibration errors as shown in previous discussions on the raw data tapes (Progress Reports 5 and 6).

Landsat 2 - Kadena AB. Landsat data were obtained for two overpasses at this site in the March-September 1976 period; unfortunately no Volz data were obtained.

Landsat 2 - Anderson AB. No Landsat data were obtained for this site in the March-September 1976 period. Volz data were obtained on just three occasions.

Landsat 2 - LACIE Sites. There appear to be thirteen coincidences of Volz measurements and Landsat data for these four NASA-Houston sites. However, not all the Volz data have yet been received, and no calibration data for the radiometers are presently available. Dr. Pitts of NASA hopes to have these available by the end of February 1977.

Landsat 1 - San Diego. Three more sets of data for San Diego overpasses were analyzed, and are presented in Figure 3 together with previously reported recent Landsat 1 data. In general the Landsat 1 data show quite good agreement with the relationships found in our original Landsat 1 investigation, although with slightly more scatter about the mean straight lines.

Raw Data Tapes

Two more raw tapes for 10-31-75 and 12-6-75 were received from GSFC, and have been analyzed. The results, shown in Table 3, confirm that the low radiance values in MSS 7 differ significantly between the raw and corrected tapes. It is concluded, if raw data tapes were used, that the MSS 7 radiance-aerosol content relationship for Landsat 2 would show a linear relationship similar to that of Landsat 1.

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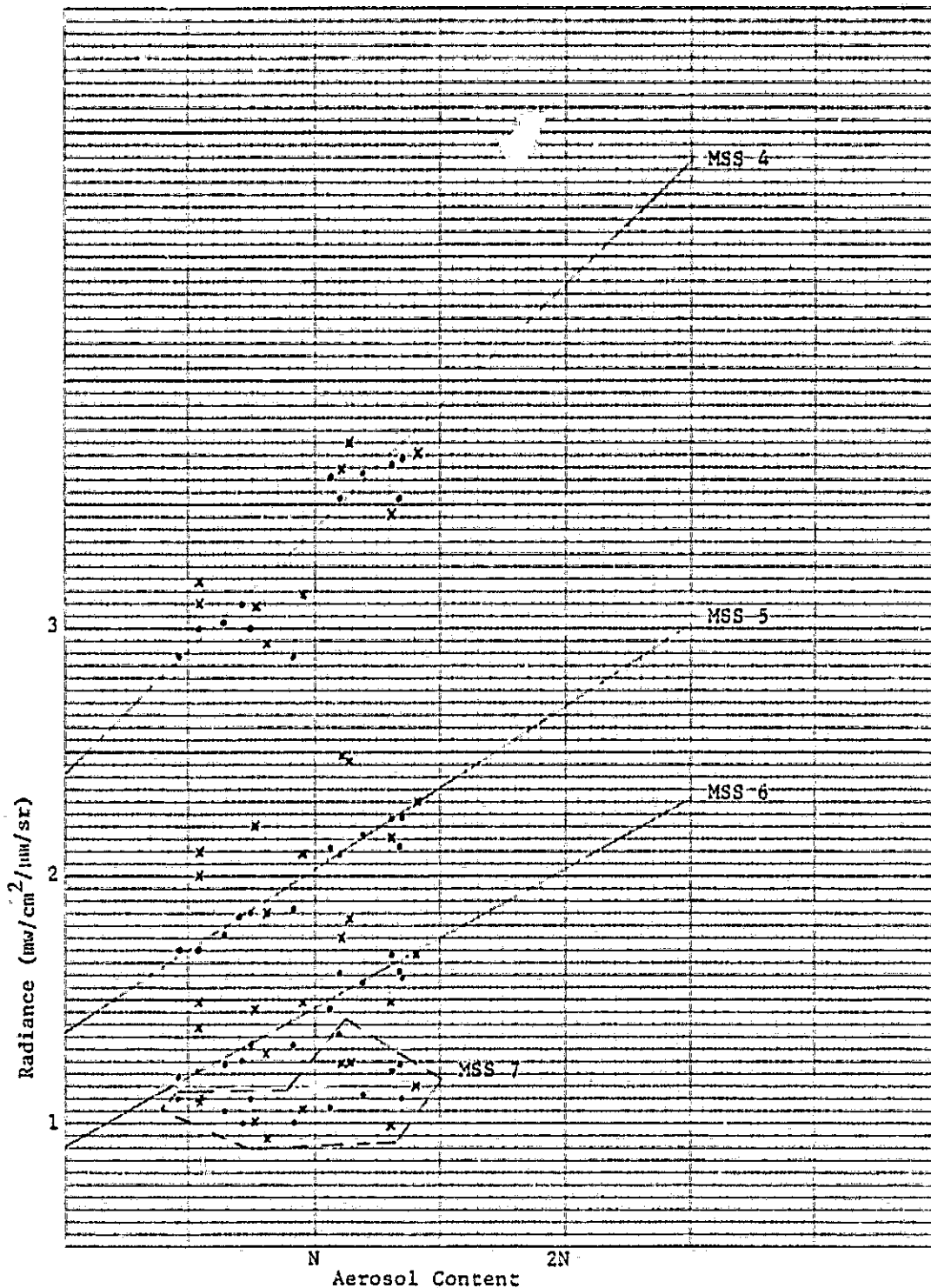


Figure 1. Radiance vs. Aerosol Content for Landsat 2, San Diego and Salton Sea (• San Diego; x Salton Sea; - Linear Regression for San Diego)

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Radiance ($\text{mw/cm}^2/\mu\text{m/sr}$)

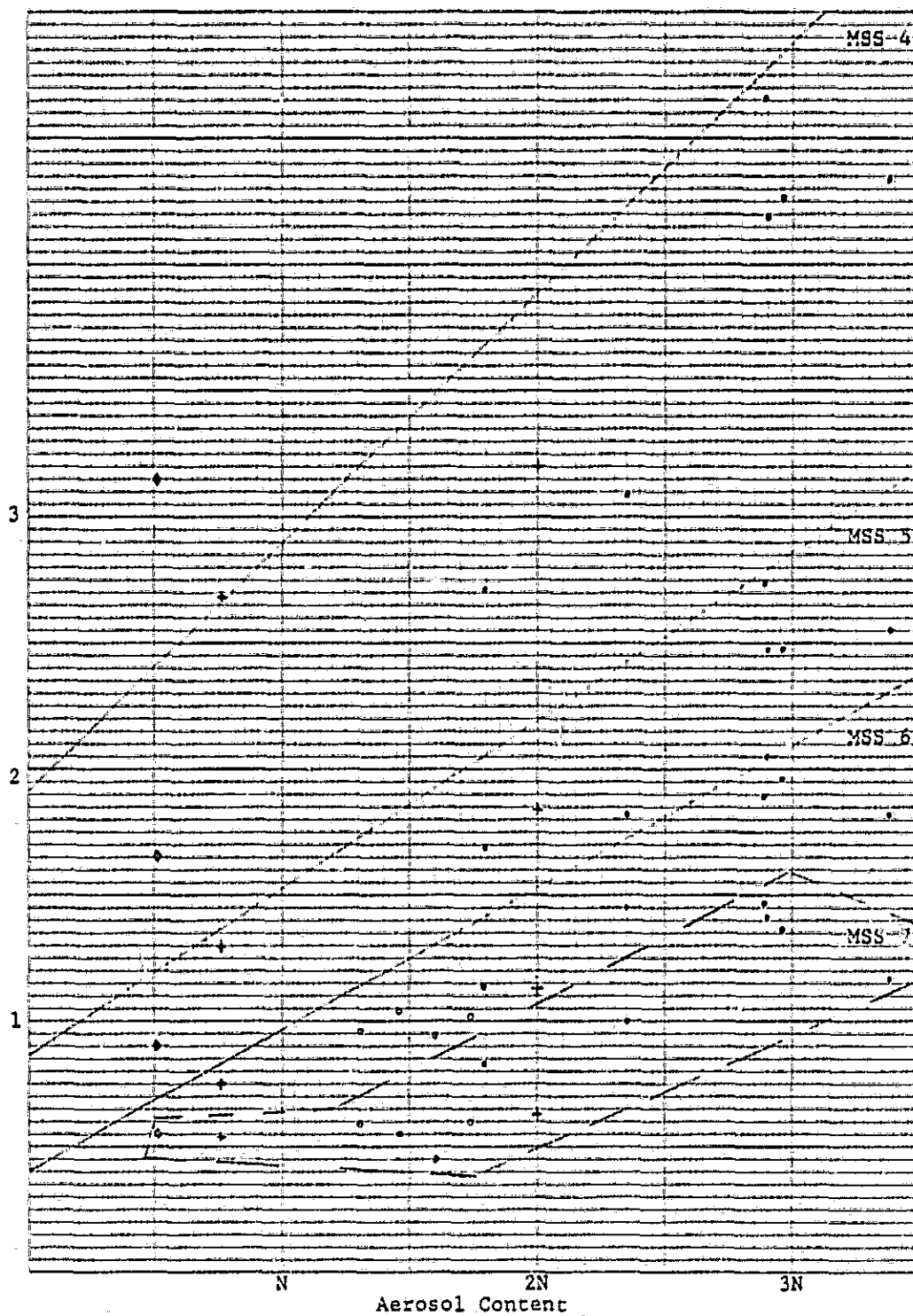


Figure 2. Radiance vs. Aerosol Content for Landsat 2,
 Other Sites (o Miami; • Atlantic City; ◇ Barrow;
 + Adrigole; - Linear Regression for San Diego)

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14-01 30 X 30 TO THE RIGHT OF THE CENTER

Radiance ($\text{mw}/\text{cm}^2/\mu\text{m}/\text{sr}$)

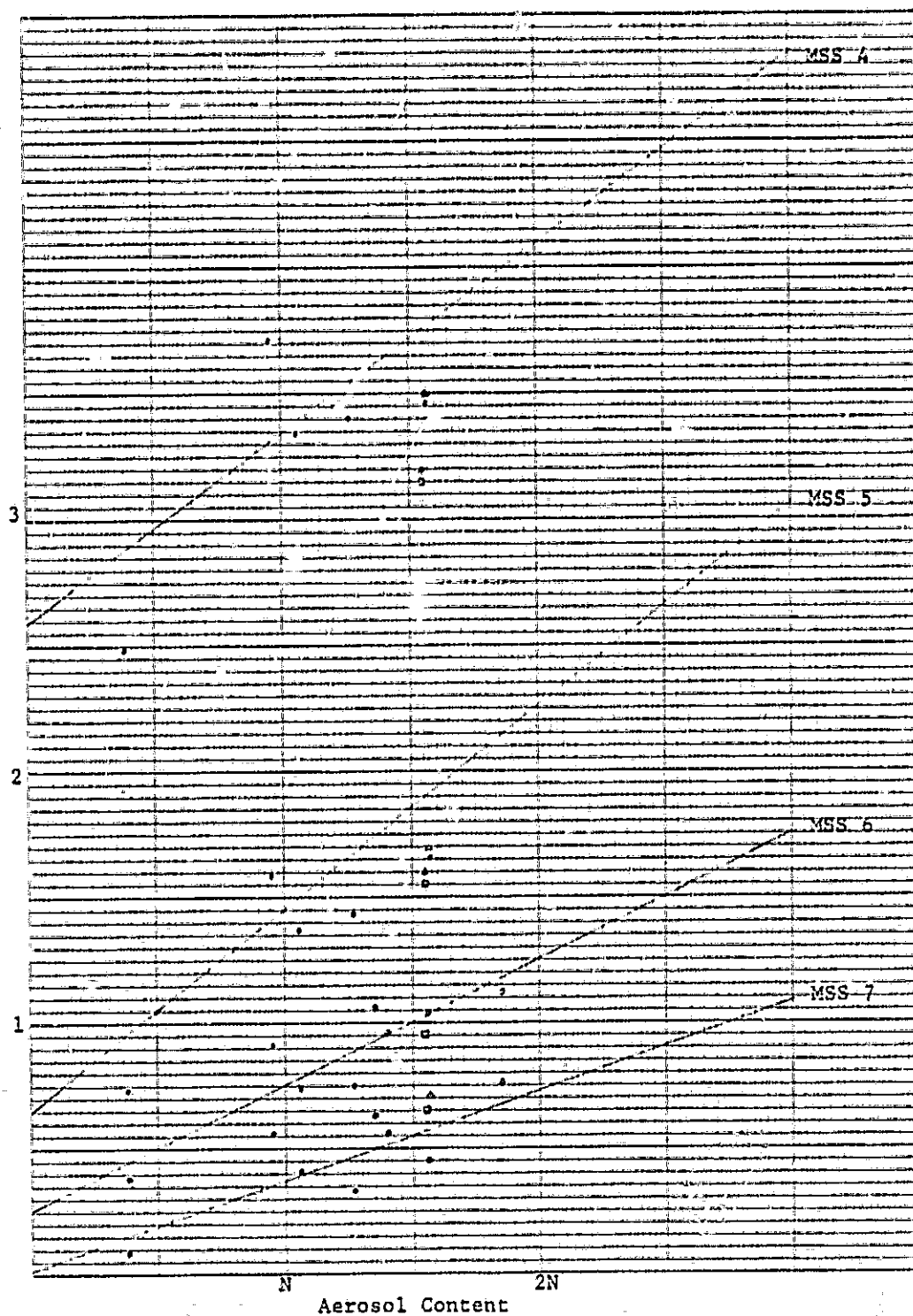


Figure 3. Radiance vs. Aerosol Content for Landsat 1, 1975-76.
 (o Miami; • San Diego; Δ Grand Prairie; □ Atlantic City;
 — Mean of Landsat 1 Data, 1972-73)

TABLE 1. LANDSAT 2 DATA

SAN DIEGO

Date	cos Sun Zenith	Volz	Normalized MSS Radiance			
			MSS4	MSS5	MSS6	MSS7
3-30-75	.73	.71N	2.59	1.38	.75	.50 ⁺
			2.68	1.17	.59*	.71*
5-5-75	.84	1.10N	3.03	1.59	1.12	.86
7-16-75	.85	1.31N	3.16	1.74	1.18	.71
8-21-75	.80	1.19N	3.13	1.67	1.07	.61*
9-26-75	.71	1.35N	3.19	1.74	1.06	.60*
10-14-75	.64	.64N	2.53	1.26	.74	.55 ⁺
11-1-75	.57	.53N	2.50	1.20	.71	.58 ⁺
11-19-75	.50	.46N	2.39	1.20	.69*	.60 ⁺
12-25-75	.42	.74N	2.50	1.35	.82	.60 ⁺
4-11-76	.73	1.07N	3.11	1.61	.97	.56*
4-29-76	.82	1.34N	3.03	1.62	1.11	.73
6-22-76	.86	.92N	2.39	1.36	.82	.50 ⁺

SALTON SEA

5-22-75	.85	1.35N	No CCT Available			
6-9-75	.87	1.41N	3.20	1.81	1.19	.65
6-27-75	.87	.82N	2.43	1.35	.78	.43*
10-31-75	.57	.54N	2.69	1.61	.98	.58 ⁺
11-18-75	.52	1.11N	3.14	1.99	1.25	.73*
12-6-75	.45	.54N	2.61	1.50	.88	.61 ⁺

*Count <1.0

⁺Count 0REPRODUCIBILITY OF THE
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Table 1

SALTON SEA...continued

Date	cos Sun Zenith	Volz	Normalized MSS Radiance			
			MSS4	MSS5	MSS6	MSS7
3-23-76	.69	.77N	2.58	1.70	.96	.51 ⁺
4-10-76	.77	1.13N	3.25	1.97	1.33	.74
5-16-76	.85	.95N	2.63	1.59	.99	.55 [*]
6-3-76	.86	1.31N	2.91	1.66	.98	.48 [*]

ADRIGOLE

4-12-76	.66	.76N	2.68	1.29	.75	.54 ⁺
8-17-76	.71	2.00N	3.20	1.83	1.12	.62 [*]

BARROW

7-18-76	.73	.51N	3.16	1.66	.90	.56 ⁺
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ATLANTIC CITY

4-18-76	.77	3.38N	4.33	2.55	1.82	1.17
4-19-76	.78	2.89N	4.66	2.74	1.89	1.47
6-12-76	.91	2.35N	3.07	1.82	1.45	1.00
7-18-76	.88	1.79N	2.71	1.59	1.14	.83
8-22-76	.83	2.96N	4.26	2.48	1.97	1.36
8-23-76	.82	2.90N	4.19	2.48	2.05	1.42

MIAMI

4-2-76	.77	1.47N	---	---	1.03	.55 [*]
4-20-76	.82	1.31N	---	---	.96	.59 [*]
6-30-76	.90	1.60N	---	---	.94	.46 [*]
8-5-76	.88	1.73N	---	---	1.02	.60 [*]

*Count <1.0

⁺Count 0

TABLE 2. LANDSAT 1 DATA

SAN DIEGO

Date	cos Sun Zenith	Volz	Normalized MSS Radiance			
			MSS4	MSS5	MSS6	MSS7
10-23-75	.59	.95N	3.71	1.59	.92	.56
12-16-75	.41	.38N	2.48	.74	.38	.08*
4-20-76	.74	1.27N	3.39	1.43	.75	.33
5-8-76	.79	1.06N	3.34	1.37	.74	.41

MIAMI

1-9-73	.55	1.57N	---	---	1.03	.45
4-9-73	.8	1.84N	---	---	1.12	.77
8-21-75	.79	1.35N	---	---	1.06	.63
9-8-75	.77	1.39N	---	---	.97	.57

ATLANTIC CITY

8-19-75	.75	1.55N	3.15	1.54	.94	.64
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GRAND PRAIRIE

10-9-75	.64	1.56N	5.53	3.50	1.69	.72
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*Count <1.0

TABLE 3

Date	Channel	Radiances ($\text{mw}/\text{cm}^2/\mu\text{m}/\text{sr}$)	
		Corrected	Raw
10-31-75	MSS 4	2.83	2.80
	5	1.70	1.69
	6	1.03	.96
	7	.61	.40
12-6-75	MSS 4	2.61	2.60
	5	1.50	1.52
	6	.88	.90
	7	.61	.22

SIGNIFICANT RESULTS

There are no significant results to report in this period.

PUBLICATIONS

A presentation of the results of this investigation was given at GSFC on October 19, 1976.

RECOMMENDATIONS

No changes in the program appear necessary at the present time.